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INFLUENCE OF PHOSPHATE ON THE TOXIC ACTION OF CUMARIN[1]

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In connection with a study of the different effects produced as the result of the action of several organic compounds on seedling wheat, presented in a former paper,[2] it was noted that the presence of phosphate in the nutrient solutions employed was able to minimize or entirely overcome the toxic effect of the cumarin on the seedlings. The effects of the cumarin on plant development are strikingly shown on the seedling wheat. The leaves are shorter and broader than is normal for wheat, and only the first leaves are usually unfolded, the other leaves remaining wholly or partially within the swollen sheath; such leaves as do break forth are usually distorted and curled or twisted. The disappearance of this characteristic behavior of the cumarin affected plants was, therefore, an additional criterion of the beneficial effect of the phosphate in the nutrient cultures, as well as the improved growth and better root development of the plants in general. The nutrient solutions contained nitrate as sodium nitrate, potassium as potassium sulphate, and the phosphate was added in the form of monocalcium phosphate.

Attention was called in the earlier paper to the fact that the observation there recorded was obtained with the calcium acid phosphate, and that the observed result may be caused, therefore, by the salt as a whole rather than by the phosphate radical contained therein, or by other specific qualities of the salt or other constituent parts, namely by its acid properties or the fact that calcium is present in the compound.

Several experiments were planned so as to eliminate the possibility of calcium producing the result noted, and to present the phosphate under different conditions, acid, neutral, and alkaline. These requirements are met by using sodium salts instead of calcium, and employing all three sodium salts of phosphoric acid, namely, the monosodium phosphate (NaH_2PO_4), which like the calcium acid phosphate of the first experiment is decidedly acid in reaction; the disodium phosphate (Na_2HPO_4), which is neutral toward phenolphthalein; and the tribasic sodium phosphate (Na_3PO_4), which is alkaline in reaction. In all other respects the culture solutions were the same in concentration and composition as described in the earlier paper, the full number of 66 cultures as there described being used, both with and without the cumarin and, as in the paper cited, comparisons are always made between solutions of like composition as far as the mineral salts are concerned. This comparison, of course, can be made between individual cultures of like composition or between groups of cultures, when members of like composition occur in both groups.

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[1] Published by permission of the Secretary of Agriculture.

[2] SCHREINER, O., and SKINNER, J. J., The toxic action of organic compounds as modified by fertilizer salts. BOT. GAZ. 54:31–48. 1912.

Effect of monosodium phosphate

The 66 culture solutions of equal concentration (80 p.p.m. of $P_2O_5+K_2O+NH_3$), but varying in composition as far as the ratios of phosphate, potash, and nitrate are concerned, were prepared according to the scheme presented in the earlier paper cited. The sets were always in duplicate, the one containing only the nutrient salts and considered as the normal set, the other containing in addition to the salts 10 p.p.m. of cumarin. The plants grew from October 17 to 29. The green weight at the termination of the experiment for the growth in the 21 cultures composed of mainly phosphatic fertilizer (one-half and more of the nutrients being phosphate) was 38.6 grams. Similarly the green weight of the cultures composed of mainly nitrogenous fertilizer was 42.0 grams, and in the cultures composed mainly of potassic fertilizers it was 41.8 grams. The results in the normal set were: for the mainly phosphatic fertilizers, 39.3 grams; for the mainly nitrogenous fertilizers, 49.9 grams; for the mainly potassic fertilizers, 46.9 grams. These results are tabulated in table I, which also gives the results relatively expressed in terms of the normal culture taken as 100.

It will be seen that the mainly phosphatic cultures gave a growth in the presence of cumarin which was nearly as good as in the cultures without cumarin. The growth relatively expressed was 98 per cent of the normal. With the other groups it was 84 and 89 per cent. The result with the monosodium phosphate is therefore similar to the action of the monocalcium phosphate reported in the earlier paper, a fact which is also shown by the appearance of the plants in the cultures composed of mainly phosphatic fertilizers, the plants having lost entirely the characteristic effect of the cumarin above referred to, an effect which is strongly marked in the cultures low in monosodium phosphate as well as in those low in calcium acid phosphate. This experiment, therefore, disposes quite effectively of the supposition that the calcium in the phosphate salt played any significant part in the observed action, since the same action in all particulars is possessed by the monosodium phosphate. There remains the question of the influence or action of the acid character of both phosphates in bringing about the observed result. For this purpose culture experiments in which the acid phosphates were replaced by neutral and even alkaline phosphates were made.

TABLE I

SHOWING THE EFFECT OF THE MAINLY PHOSPHATIC, MAINLY NITROGENOUS, AND MAINLY POTASSIC FERTILIZERS ON CUMARIN

Phosphate as monosodium phosphate

FERTILIZERS COMPOSED OF 50 TO 100 PER CENT OF	GREEN WEIGHT		RELATIVE GROWTH (NORMAL =100)
	Normal	With 10 p.p.m. cumarin	
	grams	grams	
Phosphate	39.3	38.6	98
Nitrate	49.9	42.0	84
Potash	46.9	41.8	89

Effect of disodium phosphate

The plants in this experiment grew from November 1 to 12, and the results are presented in table II, the grouping being again made on the basis of the composition of the nutrient salts in the cultures, that is, into the groups mainly phosphatic, mainly nitrogenous, and mainly potassic.

TABLE II

SHOWING THE EFFECT OF THE MAINLY PHOSPHATIC, MAINLY NITROGENOUS, AND MAINLY POTASSIC FERTILIZERS ON CUMARIN

Phosphate as disodium phosphate

FERTILIZERS COMPOSED OF 50 TO 100 PER CENT OF	GREEN WEIGHT		RELATIVE GROWTH (NORMAL =100)
	Normal	With 10 p.p.m. cumarin	
	grams	grams	
Phosphate	36.3	34.1	94
Nitrate	45.8	40.3	88
Potash	44.5	38.2	86

Here again the effect of the mainly phosphatic fertilizers is the same as with the monobasic salts already discussed, although this effect is not as marked in this experiment. There remains the trisodium phosphate of alkaline reaction to be studied in this regard.

Effect of trisodium phosphate

The plants in this experiment grew from November 29 to December 10 and the results are given in table III.

TABLE III

SHOWING THE EFFECT OF THE MAINLY PHOSPHATIC, MAINLY NITROGENOUS, AND MAINLY POTASSIC FERTILIZERS ON CUMARIN

Phosphate as trisodium phosphate

FERTILIZERS COMPOSED OF 50 TO 100 PER CENT OF	GREEN WEIGHT		RELATIVE GROWTH (NORMAL =100)
	Normal	With 10 p.p.m. cumarin	
	grams	grams	
Phosphate	37.0	33.9	91
Nitrate	42.4	34.6	81
Potash	42.9	31.7	74

These figures show that the effect of this alkaline reacting tribasic phosphate has the same effect in overcoming the toxic action of the cumarin as had the calcium acid phosphate, the monosodium phosphate, and the disodium phosphate. The reaction of these various phosphates, and probably also the presence of the calcium, appears to modify this action, as indicated by the different figures, but it in nowise determines the effect itself. The conclusion seems warranted that the peculiar action of these phosphate salts in overcoming the toxic action of cumarin is due to the phosphate radical and not to the presence of any particular base, or the acid or alkaline reaction of the nutrient solution.

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